UTILIZATION OF GENERATIVE AI IN GREEN WORK ENVIRONMENT SIMULATION FOR WORK INTEGRATED LEARNING PROGRAM BASED ON ENVIRONMENTALLY FRIENDLY INDUSTRY IN VOCATIONAL EDUCATION INSTITUTIONS

I Nyoman Suputra[1], Andi Basuki[2], Buyung Adi Dharma[3], Ari Gunawan[4], Afis Baghiz Syaifruddin[5]
[1,2,3,4]Universitas Negeri Malang, Malang, Indonesia
[5]Universitas Gadjah Mada, Yogyakarta, Indonesia
Email: nyoman.suputra.fe@um.ac.id

Abstract

The development of artificial intelligence technology, particularly Generative Artificial Intelligence (AI), presents new opportunities for innovative learning methods in vocational Education. This study aims to utilise Generative AI in creating a green work environment simulation as a learning medium for Work-Integrated Learning (WIL), with a focus on environmental and eco-friendly industries. This simulation is designed to provide an in-depth and interactive learning experience while strengthening students' competence in applying sustainability principles and green work practices in the industrial world. The research method employed is an experiment involving the development of a Generative AI-based simulation prototype that integrates elements of a green work environment, including waste management, energy efficiency, and the utilisation of renewable resources. The research participants were vocational program students who participated in Work-Integrated Learning (WIL). The evaluation was conducted by measuring the increase in understanding of the concept of green industry and the practical skills acquired through simulation. The study's results showed that the use of Generative AI-based simulation significantly increased students' learning motivation, theoretical understanding, and practical skills compared to conventional learning methods. In addition, this simulation also facilitates the development of soft skills, such as decision-making and problem-solving, in the context of green work. Thus, the use of Generative AI in green work environment simulations makes a positive contribution to improving the quality of environmentally friendly industry-based Work-Integrated Learning (WIL) Programs in vocational Education institutions. This study offers recommendations for vocational Education institutions to adopt AI technology, supporting adaptive, innovative, and sustainable learning processes that produce a competent and environmentally conscious workforce.

***Keywords**: Generative AI, Green Work Environment, Work Integrated Learning.*

A. INTRODUCTION

Rapid industrial development and changes in digital technology currently require vocational Education institutions to prepare human resources who are not

only technically competent but also have awareness and the ability to apply the principles of environmental sustainability. Green Skills Education encourages its integration into the vocational school curriculum, enabling students to be more aware of environmental conservation and the responsible use of technology. To prepare graduates for the era of the ever-growing green industry (Abo et al., 2024), the concept of an environmentally friendly industry, also known as a green industry, is crucial in addressing global challenges such as limited natural resources, climate change, and environmental degradation. Therefore, there is a strategic need to incorporate sustainability elements into vocational Education programs (Cabral et al., 2019)

One practical approach to link Theory with industrial practice is the Work Integrated Learning (WIL) Program, which integrates workplace learning into Education. However, the challenge in implementing green industry-based Work-Integrated Learning (WIL) lies in providing realistic and immersive learning experiences without relying on internship opportunities in related industries. Therefore, interactive and adaptive learning methods must be developed to simulate green work environments. The construction of a "sustainable construction laboratory" is a concrete example of how work-based learning (WIL) can combine Theory and practice in an environmentally friendly context (V Bjorch et al., 2024)

Generative Artificial Intelligence (AI) technology is an innovative solution for virtual learning simulations that can simulate complex and dynamic work scenarios. Digital innovations, such as generative AI, significantly enhance sustainability through eco-innovation in digital Education, thereby strengthening the alignment of learning outcomes with the Sustainable Development Goals (Low et al., 2025). Using data and intelligent algorithms, AI can create realistic content, interactions, and responses, thus simulating various situations in a favourable work environment, such as the use of renewable energy, waste management, and the application of rational practices (Bolon et al., 2024). By utilising this technology in WIL programs, students can learn and practice in a green industry context without needing to be directly on the work site.

Integrating Generative AI into educational environments has great transformational potential, as it personalises learning, increases accessibility, and reduces resource use, thereby promoting educational sustainability (Al Qaysi et al., 2025). However, the adoption of AI in vocational Education, especially for green industry-based work-integrated learning (WIL) programs, still faces many challenges. These include limited infrastructure, teacher availability, and the need for curricula to be up-to-date with industry practices and technologies. Therefore, this study aims to develop and evaluate a green work environment model based on generative artificial intelligence as an innovative learning tool for work-integrated learning (WIL) programs. Additionally, this study offers suggestions on how this technology can be applied in vocational Education institutions.

By presenting an AI-based green work simulation, it is expected that students will more easily understand the concepts and practices of environmentally friendly industries while improving the technical and soft skills required in the workplace (Abulibdeh et al., 2024). This research is also expected to make a contribution to the vocational Education literature on the integration of innovative technology to support the development of competent and environmentally aware human resources. In

addition, the results of this study can serve as a reference for Education policymakers and WIL program managers in developing innovative learning strategies that are relevant to the needs of the future green industry.

B. LITERATURE REVIEW

1. Generative Artificial Intelligence in Vocational Education

Generative Artificial Intelligence (AI) is a branch of AI technology that can generate new content and intelligent interactions based on existing data. In the context of Education, generative AI has been used to create adaptive learning media and interactive simulations, thereby increasing the effectiveness of the learning process. The use of generative AI in learning simulations can enhance student motivation and engagement by providing personal and realistic learning experiences (Guan et al., 2020). Additionally, this technology can provide real-time feedback, which is very useful for learning practical skills (Wang et al., 2024). In the field of vocational Education, the use of generative AI has great potential to support practice-based learning, especially in Work-Integrated Learning (WIL) programs that integrate Theory and real-world work experience. The development of AI-based simulations enables students to practice in a virtual environment that mimics real-world work situations, thereby improving both technical skills and soft skills, such as problem-solving and decision-making (Rashid et al., 2024).

2. Green Work Environment and Eco-Friendly Industry Simulation

The green industry emphasises the application of sustainability principles, which include reducing negative environmental impacts through the efficient management of resources, energy, and waste (Li, 2024). In the context of vocational Education, green work environment simulations play a crucial role in equipping students with the understanding and skills required by the green industry. These simulations provide a safe and flexible learning environment for understanding green work practices, including waste management, renewable energy utilisation, and carbon emission reduction strategies (Contini et al., 2025). Virtual simulations that integrate green work environment principles can increase students' environmental awareness and job readiness in the sustainable industrial sector (Nystrom et al., 2024). With the advancement of digital technology, these simulations can be increasingly combined with generative AI to create more dynamic, realistic, and interactive learning scenarios.

C. METHOD

The development of a generative AI-based green workplace simulation for Work-Integrated Learning (WIL) Programs follows a structured approach guided by the ADDIE model, which includes five phases: Analysis, Design, Development, Implementation, and Evaluation.

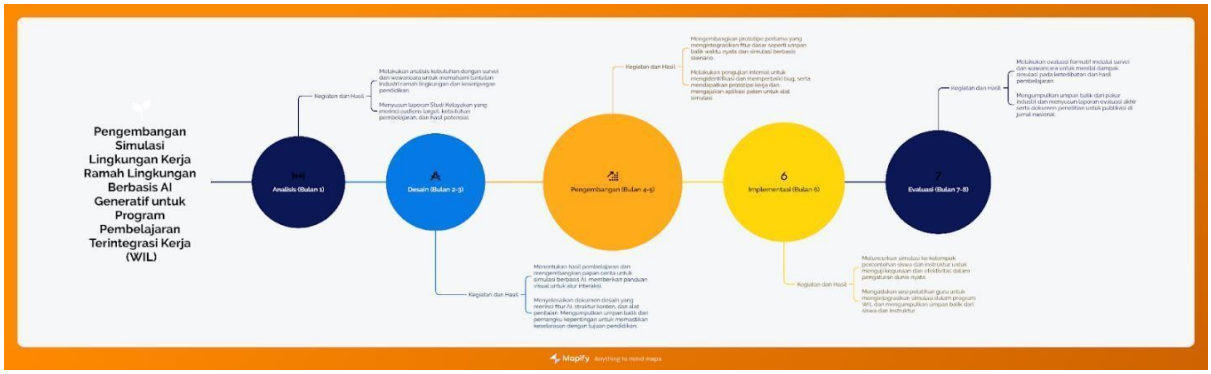

Figure 1. Research Methods

Each phase is critical to the successful creation and implementation of the simulation tool, which aims to enhance vocational Education and prepare students for careers in the green industry. The process will span 8 months, with clear objectives, activities, and outcomes outlined in each phase.

1. **Analysis (Month 1)**

The first phase, Analysis, establishes the foundation for the entire project by identifying learning needs and simulation objectives. This phase focuses on understanding the current state of vocational education, green industry needs, and the potential role of AI in shaping this domain. During the first two weeks, a needs analysis will be conducted, including surveys and interviews with educators and industry experts to gather insights into green industry demand and education gaps. In weeks 3 and 4, a literature review will be conducted to explore existing AI applications in vocational education and green work environments. The main deliverable in this phase is the Feasibility Study report, which will detail the target audience, learning needs, and potential outcomes. Additionally, a social media presence will be established for continued project dissemination and stakeholder engagement.

2. **Design (Month 2-3)**

In the Design phase, the focus shifts to planning the structure and components of the learning materials. The goal is to define learning outcomes, design content, and select assessment strategies. In the first two weeks, clear learning outcomes will be defined, and the project team will begin developing a storyboard for the AI-driven simulation. This storyboard will provide a visual guide to the simulation flow, interaction patterns, and key features. In weeks 3 and 4, a design document will be completed, detailing the AI features, content structure, interactivity, and assessment tools. Feedback will be gathered from stakeholders, including teachers and industry professionals, to ensure that the design aligns with vocational education goals and industry needs. The final output of this phase will be a Prototype/Preliminary Design document, outlining the structure, features, and design principles of the simulation.

3. **Development (Month 4-5)**

The Development phase is where the actual AI-based simulation is built. During the first two weeks of month 4, the team will start developing the first prototype based on the design document. This prototype will integrate basic features

such as AI-driven real-time feedback and scenario-based simulation. Weeks 3 and 4 will focus on refining the prototype, addressing technical issues, and incorporating further AI features. In month 5, the team will conduct internal testing to identify and fix bugs, improve the performance and usability of the simulation. The main deliverables in this phase are a working prototype of the AI-driven green workplace simulation and the filing of a patent application for the AI simulation tool under the simplified patent scheme. This will secure the intellectual property rights for the technology developed.

4. Implementation (Month 6)

The Implementation phase marks the launch of the prototype to the target audience. In the first two weeks of month 6, the AI-driven simulation will be deployed to a pilot group of vocational students and instructors. These groups will test the simulation in a real-world setting, allowing the project team to gather feedback on usability and effectiveness. Weeks 3 and 4 will involve teacher training sessions, where instructors will be trained on how to integrate the simulation into their Work Integrated Learning (WIL) program. Feedback will be gathered from students and instructors to evaluate the impact of the simulation on learning outcomes and engagement. The final deliverables for this phase include a Showcase, where the simulation prototype will be showcased to the public, industry partners, and academic institutions, as well as ongoing social media updates to share progress and generate interest.

5. Evaluation (Month 7-8)

The final phase, Evaluation, focuses on assessing the effectiveness of the AI simulation. Evaluation is an ongoing process throughout development, but becomes especially important in this phase. During the first two weeks of month 7, formative evaluation will be conducted through surveys, quizzes, and interviews with students and instructors. This will help assess the impact of the simulation on engagement and learning outcomes. In weeks 3 and 4, the project team will gather feedback from industry experts to evaluate whether the simulation aligns with a real-world work environment. In month 8, the project team will compile all feedback, analyze the data, and prepare a final evaluation report. This report will include recommendations for scaling the AI-based simulation to other vocational institutions and industries. Key deliverables for this phase include a research paper to be submitted to a national journal (SINTA 4) and posters for academic and industry conferences to present the project findings.

D. RESULTS AND DISCUSSION

1. Preliminary Study

Vocational Education institutions in Indonesia play a crucial role in preparing skilled workers who meet industry needs. However, industrial developments that increasingly emphasize the principles of sustainability and environmentally friendly technology require a more relevant and adaptive learning approach. The challenges faced include limited green work environment simulation facilities, lack of integration of advanced technology in the curriculum, and minimal active collaboration between

schools and green industries. On the other hand, technological advances such as Generative AI provide great opportunities to create realistic, dynamic, and environmentally friendly work environment simulations. This technology enables students to experience the working environment of an ecologically friendly industry through the Work-Integrated Learning (WIL) approach without relying entirely on real-world practices that often have limited access.

Through the use of Generative AI, vocational learning can be transformed into more contextual, interactive, and supportive of the development of 21st-century skills, such as collaboration, technological literacy, and environmental awareness. However, this integration requires a structured design and support from a collaborative learning ecosystem. This study aims to develop a green work environment simulation based on Generative AI as part of the WIL program to improve the readiness of vocational Education graduates to face the world of work based on green industry adaptively and sustainably.

Table 1. Analysis of the Need for Learning Media Facilities Related to Modern Agricultural Tourism

No	Question	Answer Options	Percentage
1	Do vocational school students and teachers need digital learning media to understand the concept of environmentally friendly industries?	Yes	80%
		No	20%
2	What types of learning media are most needed to support the Work Integrated Learning (WIL) program?	Video Tutorial	35%
		E-Book	40%
		Interactive Online Training	15%
3	Are students and teachers open to the use of Generative AI-based simulations for work practice?	Yes	72%
		No	28%
4	Does industrial mentoring in the form of WIL need to be carried out continuously in vocational schools?	Yes	70%
		No	30%
5	Do students find it difficult to access direct green industry experience?	Yes	81%
		No	19%
6	Can the use of virtual simulations such as green work environments help understand industrial work processes?	Yes	85%
		No	15%
7	Does the learning in vocational schools instill sustainability and environmental values?	Yes	10%
		No	28%
		Not yet optimal	62%
8	Are students interested in a digital simulation-based industrial training program?	Yes	74%
		No	26%
9	Are schools ready to collaborate with industry in technology-based WIL program collaboration schemes?	Yes	78%
		No	22%
10	Is an innovative technology-based learning system needed to support vocational school students' work readiness?	Very Necessary	60%
		Need	30%
		No need	10%

Based on the results of the needs analysis conducted among students and teachers in vocational Education institutions, it was found that most respondents were aware of the importance of digital learning media in supporting an understanding of environmentally friendly work environments. As many as 89% of respondents stated

that they needed digital learning media, with e-books (40%) and video tutorials (35%) being the most popular types of media. Both of these media are considered practical and easy to use in the learning process in vocational schools. As many as 72% of respondents also stated that they were open to using new learning methods based on work environment simulations, especially those that depict green industry conditions. Interactive multimedia based on simulations can enhance the learning outcomes of vocational students, supporting the adoption of new learning methods that incorporate work environment simulations (Hidayat et al., 2024). This indicates that there is an excellent opportunity to offer a more realistic learning experience that is relevant to the needs of today's workforce. Even so, 70% of respondents considered that mentoring and guidance from schools and the industrial world were still very much needed so that students could understand the work process as a whole. Digital transformation is essential in vocational Education as a collaborative effort involving various stakeholders, including schools and industry, to provide broader benefits (Xu et al., 2024)

It was also found that 81% of respondents still had difficulty gaining direct experience in a work environment oriented towards the principles of sustainability. This is one of the key reasons for developing a learning model that enables students to understand environmentally friendly work processes without always requiring an industrial setting. As many as 85% stated that the work simulation method would be beneficial in the learning process and improve students' readiness for the workforce. Simulation-based learning environments can effectively prepare students for complex work environments by providing realistic scenarios that enhance decision-making skills and foster an understanding of sustainable practices. Simulation-based learning environments can effectively prepare students for complex work environments by providing realistic scenarios that enhance decision-making skills and foster an understanding of sustainable practices (Nurdin et al., 2022). In terms of curriculum, only 10% stated that current learning has effectively taught sustainability values, while 62% stated that these values have not been fully maximised. This highlights the need to update the learning approach to place greater emphasis on the principles of the green industry and a sustainable environment. The integration of sustainability principles in vocational Education in Indonesia emphasises that learning approaches that emphasise the principles of green industry and a sustainable environment need to be updated to meet the needs of today's workforce (Mustofa et al., 2024).

As many as 74% of students stated that they were interested in participating in training or learning programs that present industry work practices through simulations. This reinforces that a more visual and applied learning approach is in high demand. Additionally, 78% stated that the school is ready to collaborate with industry through learning activities that are integrated with the world of work. Industrial Education, achieved through collaboration between the industrial world and vocational schools, is a solution to preparing graduates who are competitive and relevant to industry needs (Hamid et al., 2022). Finally, as many as 90% of respondents considered that there is a need for a more innovative learning system that closely mimics real industrial conditions so that students are better prepared to enter the workforce. In vocational Education and professional training, simulations are often designed to help students learn how to engage in professional practice (Tzafilkou et

al., 2022). These data show that the development of learning through environmentally friendly work environment simulations is urgently needed to improve student competence and strengthen the connection between Education and industry.

2. Curriculum Development and Learning Materials

a. Learning Concept

In facing the challenges of globalization and climate change, the education sector, especially in vocational schools, must be able to answer the needs of industry that are increasingly moving towards the principles of sustainability and environmental friendliness. Therefore, the development of curriculum and learning materials that are relevant to the needs of the green industry is very important. The concept of learning based on environmentally friendly work environment simulation (green work simulation) is here to bridge the gap between the theory taught in schools and real practice in the industrial world.

This curriculum is designed to provide students with skills that are not only technical in nature, but also introduce them to the values of sustainability that are key to the world of work in the era of industry 4.0. Through a project-based learning approach, experiential learning, and contextual teaching, students are involved in real simulations that require them to plan, implement, and evaluate environmentally friendly work processes. Thus, they not only understand the theory of energy efficiency and waste management, but also learn how to apply them in the industrial world. In addition, the use of technology in the form of digital modules, application-based simulations, and e-learning platforms supports learning flexibility that allows students to learn anytime and anywhere. Thus, this curriculum is expected to produce graduates who are ready to face the demands of sustainable industry and contribute to the development of an inclusive and competitive green economy.

Figure 2. Green Work Simulation Learning Materials and Media

Learning materials are developed in the form of interactive digital modules, work process simulation videos, green industry themed board games, and case study-based practice worksheets. All materials are linked to simulations of the world of work in manufacturing, waste management, energy efficient production systems, and environmentally based quality control. The learning platform is also equipped with a competency achievement monitoring dashboard system to make it easier for teachers and students to monitor learning progress. Students will learn in a simulation room (smart learning corner or green mini-lab) designed to resemble a real workplace, complete with production scenarios, environmental audit processes, and efficiency evaluations. In this practical activity, participants not only work technically, but are also invited to analyze the impact of the production process on the environment, as well as design sustainable improvement solutions.

Figure 3. Implementation of Experiential Learning through Environmentally Friendly Production Process Simulation

The uniqueness of this curriculum lies in the involvement of students in real work roles in turns (job rotation simulation), where they experience firsthand the work process from planning, production, to waste control. This learning also develops soft skills such as leadership, work communication, time management, and environmental responsibility, which are essential competencies in the world of work. In addition, participants are invited to build a digital portfolio that contains documentation of work practices, case study reports, and personal reflections.

Figure 4. Integration of Green Industry Values in Vocational Curriculum

This curriculum also integrates sustainability values into all vocational subjects, for example through the themes of energy efficiency, 3R (Reduce, Reuse, Recycle), and circular economy, so that students understand that sustainability is part of the daily work process. At the end of the program, participants will take part in a quality and environmental audit simulation, and present work process innovations that have been designed during the training. Overall, this learning concept aims to create vocational school graduates who are not only technically competent, but also have environmental awareness, are adaptive to industry changes, and are ready to contribute to a sustainable world of work.

b. Platform Development

This Generative AI-based chatbot platform is designed to support the implementation of green work environment simulations in the Work Integrated Learning (WIL) program in vocational Education institutions.

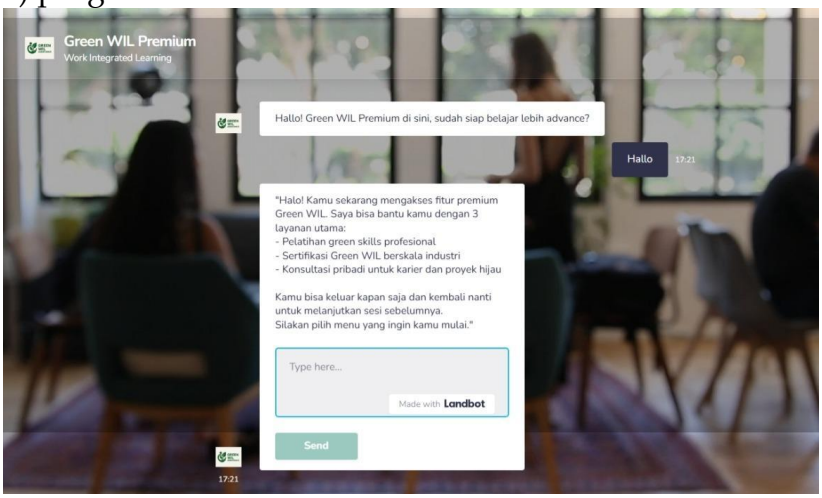

Figure 5. Green WIL Chatbot

The goal is to provide contextual learning experiences to students through realistic digital interactions based on the principles of environmentally friendly

industries. This chatbot presents work scenarios that reflect sustainable practices, such as waste management, energy efficiency, and the use of low-carbon raw materials. In its interactions, the chatbot can act as an industry mentor, superior, or coworker who provides instructions, challenges, and feedback based on the role and context of the student's expertise, such as engineering, office, or agribusiness.

In addition, the chatbot is equipped with an eco-skills assessment module that allows students to answer quizzes or reflective questions dynamically to measure their understanding of environmentally friendly practices. There is also a decision-making challenge feature where students are asked to respond to real work situations, such as determining energy-saving procedures or choosing work strategies based on zero-waste principles, which will then be analyzed by the chatbot. The system provides adaptive feedback and suggests further learning paths based on user performance, both for independent learning and integrated into the curriculum. All interactions are systematically recorded so that teachers can monitor the development of student competencies and use them as part of evaluation or digital portfolio development. With the implementation of this platform, vocational Education institutions can present a flexible green industry-based learning experience, even without physical ties to the business world. This supports the transformation of vocational Education that is adaptive to the challenges of the green economy and the Industrial Revolution 5.0.

3. Material Validation Test

As part of the development of the Work Integrated Learning (WIL) program based on environmentally friendly industries in vocational education institutions, a validation test was conducted on learning materials that utilize Generative AI in the Green Work Environment simulation. This validation aims to assess the feasibility of the content, quality of presentation, and relevance of the material to the needs of the world of work that is oriented towards green practices and technological transformation. The validation process was carried out by three expert validators who have backgrounds in vocational education, intelligent digital technology, and the development of environmentally friendly industries.

The assessment instrument consists of 20 indicators covering various aspects ranging from the suitability of the material to the learning objectives, the sophistication of the content and technology, contextualization to the green work environment, to interactivity and potential integration in the industrial ecosystem 4.0. The assessment is carried out using a scale of 1-5, where the final results are analyzed in the form of a total score, percentage of eligibility, and evaluation category. The data from the validation test results of the learning materials are presented in Table 2 below.

Table 2. Learning material test assessment data

No	Selected Criteria	Validator Value 1	Validator Value 2	Validator Value 3	Total	Percentage	Evaluation Criteria
1	Suitability of materials to learning objectives	4	5	4	13	86.7	Good
2	Suitability of materials to the context of green industry	5	4	5	14	93.3	Very good

3	Accuracy of environmentally friendly work environment simulation content	4	4	4	12	80.0	Enough
4	Up-to-date materials with Generative AI technology	5	5	5	15	100.0	Very good
5	Systematic presentation of material	3	4	4	11	73.3	Enough
6	The language used is easy to understand	4	5	5	14	93.3	Very good
7	Language suitability for vocational students	4	4	5	13	86.7	Good
8	Attractive visualization of green work environment	5	5	4	14	93.3	Very good
9	Interactivity in presentation (if digital)	5	4	5	14	93.3	Very good
10	AI-based learning innovation for green industry	4	4	4	12	80.0	Enough
11	Suitability of illustrations/images to the content of the material	5	4	5	14	93.3	Very Good
12	Depth of material according to target education level	5	5	5	15	100.0	Very good
13	Integration of local wisdom values in the context of green industry	4	4	5	13	86.7	Good
14	Relevance of material to local character and environmental issues	4	4	4	12	80.0	Enough
15	The accuracy of the examples given	5	4	5	14	93.3	Very good
16	Materials support contextual learning	5	5	5	15	100.0	Very good
17	Suitability of materials with the latest technological developments	4	4	4	12	80.0	Enough
18	The material encourages active involvement of participants in the simulation.	4	5	4	13	86.7	Good
19	There are elements of competency evaluation/measurement	5	5	5	15	100.0	Very good
20	Material potential in building a technology-based village export ecosystem	5	5	5	15	100.0	Very good
Average					**13.5**	**90.0**	**Good**

Based on Table 2, three expert validators consisting of vocational education experts, artificial intelligence (AI) technology, and green industry assessed 20 indicators to test the quality, suitability, and effectiveness of digital learning materials. This material is designed to support Work Integrated Learning (WIL) based on Green Work Environment simulations with the utilization of Generative AI technology, which is intended for students in vocational education institutions in facing the transformation towards an environmentally friendly industry. The validation results show that the material obtained an average total score of 13.5 out of a maximum of 15 points, with a feasibility percentage of 90.0%. Based on the evaluation criteria, the material is included in the "Good" category and is highly recommended for implementation in future-oriented contextual learning.

Most of the indicators with the highest scores (100%) include the latest references and technologies, the depth of the material according to the level of vocational education, support for contextual learning, clarity of competency evaluation, and the potential to encourage a technology-based green industry ecosystem. Contextual learning strategies combined with a clear competency-based assessment framework contribute to students' deeper understanding and readiness for real-world application, especially in the green technology sector (Kim et al., 2021). These results indicate that the material has been designed with an innovative approach that not only delivers substantial content but also stimulates the development of students' mindsets towards sustainability, technology, and green work practices that are relevant to the modern industrial world. In addition, several other aspects also show "Very Good" quality such as the interactivity of digital presentation, the suitability of the language to the target audience, illustrations that support the content, and visual appeal. Innovative learning design encourages critical thinking skills and a sustainable mindset that are very important for green industry practices (Al-Fadhli et al., 2020). This shows that the material not only presents cognitive content but also pays attention to attractive and communicative digital learning design factors. However, there are several indicators with the category of “Sufficient” (values between 73.3–80%), such as systematic presentation, accuracy of information, and local wisdom values displayed in the content. This is important input for improvement, especially in the aspects of narrative preparation, local context, and stronger integration of cultural values in the green work simulation.

Overall, the results of this validation indicate that the learning materials are very feasible to be used as part of vocational learning innovations based on smart technology and sustainable environment. The materials have great potential to be developed into interactive and applicable digital modules in supporting project-based learning systems, active involvement of students, and the formation of environmentally aware work readiness in the future vocational education ecosystem. The learning strategies used to improve green skills use project-based and problem-based approaches that encourage critical, innovative, and responsible thinking (Saputri et al., 2024)

4. Media Validation Test

Validation of learning media is carried out as part of an important stage in ensuring the quality and feasibility of the Generative AI- based Green Work

Environment simulation that is being developed. This media is designed to support the Work Integrated Learning (WIL) program in vocational education institutions, by carrying the principles of environmentally friendly industries. Validation is carried out by three experts from the fields of vocational education, digital learning technology, and green industry development. The assessment includes 20 indicators that assess aspects of media content, visual appearance, interactivity, and relevance to the learning context and industry needs. Each validator gives a score in the range of 1 to 5, so that the maximum score for each indicator is 15. The assessment results data are presented in Table 3 below:

Table 3. Learning media test assessment data

No	Selected Criteria	Validator Value 1	Validator Value 2	Validator Value 3	Total	Percentage	Evaluation Criteria
1	Conformity of media content with the Green Work Environment and WIL themes	4	5	5	14	93.3	Good
2	Visual appeal (book design / video quality)	5	4	5	14	93.3	Very good
3	Quality of graphics and supporting illustrations	4	4	4	12	80.0	Enough
4	The appeal of visual and graphic displays	5	5	5	15	100.0	Very good
5	Appropriate use of colors and fonts	3	4	4	11	73.3	Enough
6	Audio and visual quality (if there is video)	4	5	5	14	93.3	Very good
7	Consistency of appearance between pages	4	4	5	13	86.7	Good
8	Suitability of media to the characteristics of vocational students	5	5	4	14	93.3	Very good
9	Relevance of content to green industry work practices	5	4	5	14	93.3	Very good
10	Innovation in the use of AI in learning simulations	4	4	4	12	80.0	Enough
11	Flexibility of access (can be opened on various devices)	5	4	5	14	93.3	Very Good
12	The benefits of media in Work Integrated Learning	5	5	5	15	100.0	Very good
13	Compliance of media content with	4	4	5	13	86.7	Good

	green vocational education values						
14	Language in communicative and easy to understand media	4	4	4	12	80.0	Enough
15	Availability of media usage instructions	5	4	5	14	93.3	Very good
16	User data security and protection	5	5	5	15	100.0	Very good
17	Accuracy of media presentation of material	4	4	4	12	80.0	Enough
18	The relationship between theory and practice in media	4	5	4	13	86.7	Good
19	Media support for independent learning	5	4	5	14	93.3	Very good
20	Media communication style according to participant character (vocational school students)	5	5	5	15	100.0	Very good
Average					**13.5**	**90.0**	**Good**

Based on Table 3, the validation test of the Green Work Environment simulation media based on Generative AI was carried out by three expert validators, consisting of vocational education experts, digital learning technology experts, and green industry practitioners. The assessment was carried out on 20 important indicators to assess the quality of content, appearance, usefulness, and feasibility of the media as a learning tool in the Work Integrated Learning (WIL) program in a vocational education environment oriented towards an environmentally friendly industry.

The validation results showed that the media obtained an average total score of 13.5 out of a maximum of 15 points with a feasibility percentage of 90.0%. Based on the evaluation criteria, this media is in the "Good" category and is highly recommended for use in green industry-based WIL learning. Interactive learning media based on Work-Integrated Learning indicates that the media is very suitable for use in supporting green industry-based vocational learning (Prohimi et al., 2024). The media is considered capable of simulating an environmentally friendly work environment with an interesting, relevant, and technology-based approach. The indicators that received the highest scores (100%) include the attractiveness of the graphic display and interactivity, the usefulness of the media in WIL learning, user data security, and the consistency of communication style that is in accordance with the characteristics of vocational students. Learning media that simulates an environmentally friendly work environment can increase the active involvement of students and their readiness for environmentally conscious work (Ahmed et al., 2024).

This shows that the media is designed not only to be visually appealing, but also to take into account important technical aspects such as data protection, usefulness in practical learning, and the connection between theory and the reality of the world of work.

Several indicators that are still in the "Sufficient" category (value 73.3–80.0%) include the quality of supporting graphics, consistency in the use of colors and fonts, use of more communicative language, and accuracy of presentation of the material. These shortcomings are important notes in further development, especially to strengthen aspects of readability, user comfort, and improve the quality of visual design so that the media becomes more intuitive and effective as a whole. Easy-to-understand language and clear design are very important for creating effective vocational learning materials so that students understand and are more motivated to face changes in the industrial world (Sari et al., 2022). Overall, the validation results show that this simulation media is very suitable for use to support the implementation of the Work Integrated Learning program which prepares vocational students to face the industrial work ecosystem that prioritizes the principles of sustainability and cutting-edge technology. This validation is a strong foundation that the media is able to function as a contextual, adaptive, and innovative learning tool to realize vocational education that is relevant to the challenges of the future green industry.

5. Platform Validation Test

Platform validation testing is an evaluative process carried out systematically to assess the feasibility, effectiveness, and functional suitability of a digital platform before it is widely implemented in the learning process. In the context of this study, the platform validation test aims to ensure that the Green Work Environment Simulation platform based on Generative AI has met quality standards and supports the needs of the Work Integrated Learning (WIL) program oriented towards environmentally friendly industries in vocational education institutions. This validation includes aspects of accessibility, user interface appearance, feature effectiveness, content relevance, data security, and support for independent and collaborative learning. Through this process, feedback is obtained from expert validators that can be used to make improvements and refinements to the platform in order to provide an optimal learning experience, in accordance with the characteristics of students and the demands of sustainable industry.

Table 4. Platform validity test assessment data

No	Selected Criteria	Validator Value 1	Validator Value 2	Validator Value 3	Total	Percentage	Evaluation Criteria
1	Platform accessibility by users	4	5	4	13	86.7	Good
2	Consistency of user interface (UI) appearance	5	4	5	14	93.3	Very good
3	Integration of environmentally friendly industrial work simulation features	4	4	4	12	80.0	Enough

4	Availability of interaction features (forums, comments, questions and answers)	5	5	5	15	100.0	Very good
5	Relevance of features to the implementation of Work Integrated Learning (WIL)	3	4	4	11	73.3	Enough
6	Multi-level access availability (admin, teacher, student, industry partner)	4	5	5	14	93.3	Very good
7	Attractive and user-friendly interface design	4	4	5	13	86.7	Good
8	Suitability of multimedia (audio, video, images) to support user understanding	5	5	4	14	93.3	Very good
9	Platform support for collaboration between users (teachers-industry-students)	5	4	5	14	93.3	Very good
10	green industry simulation	4	4	4	12	80.0	Enough
11	Clarity of navigation and flow of use of features within the platform	5	4	5	14	93.3	Very Good
12	User data security and protection	5	5	5	15	100.0	Very good
13	The usefulness of platforms in digital learning	4	4	5	13	86.7	Good
14	Video-based self-training and evaluation features	4	4	4	12	80.0	Enough
15	Participant reporting & progress tracking dashboard	5	4	5	14	93.3	Very good
16	Supporting information about environmentally friendly technology	5	5	5	15	100.0	Very good
17	Effectiveness of delivering educational messages through digital elements	4	4	4	12	80.0	Enough

18	Flexibility of use across devices and operating systems	4	5	4	13	86.7	Good
19	Availability of instructions for use and FAQs	5	4	5	14	93.3	Very good
20	Consistency of appearance and content structure across platform features	5	5	5	15	100.0	Very good
Average					**13.4**	**89.3**	**Good**

Based on table 4, the platform validation test was conducted by three expert validators who have backgrounds in educational technology, software engineering, and vocational curriculum development based on environmentally friendly industries. The assessment was conducted on 20 main indicators that reflect the technical, functional, aesthetic, and educational aspects of the Green Work Environment Simulation platform based on Generative AI developed to support the implementation of the Work Integrated Learning (WIL) program in vocational education institutions.

The validation results show that the average total score of all indicators is 13.4 out of a maximum of 15, with a feasibility percentage of 89.3%, so it is included in the "Good" category. Several indicators received the highest scores (100%), including the availability of interactive features such as forums and Q&A, security and protection of user data, completeness of information on local tourism and agriculture as part of the green work environment simulation context, and consistency of content appearance and structure across platform features. Interactive, safe, and contextual learning media design is essential to increase the acceptance and effectiveness of learning (Zardari et al., 2021). This indicates that the platform has a strong foundation in terms of interactivity, digital security, contextualization of learning, and professional design.

Other indicators that also received a "Very Good" rating (above 90%) include multi-level user access (admin, mentor, participant), support for collaboration between village MSME actors as industry partners, clear navigation, and a user progress reporting and tracking dashboard. The well-designed dashboard allows users with teacher profiles to monitor student progress in specific courses, including scores obtained for exams taken and completion rates for each session (Huang et al., 2021). This shows that the platform has been designed with the needs of users from various backgrounds in mind and supports real-time monitoring of learning progress.

However, several indicators are still in the "Sufficient" category (value 73.3–80%), such as the relevance of features to the village business incubation process, innovation of educational features based on simulations, effectiveness of delivering educational messages, and the existence of independent training through videos and quizzes. The suitability between platform features and the business incubation process greatly affects the effectiveness of the support provided to users (Gunawan et al., 2023). This category indicates that although the platform is quite feasible, there is still room for improvement, especially in the integration of more interactive

technology simulations, as well as strengthening independent training materials to further stimulate user reflection and understanding in depth.

Overall, the results of the validation test confirm that the developed platform has great potential to support green industry project-based learning in the Work Integrated Learning scheme. This platform not only meets the technical and pedagogical aspects, but also has high flexibility and adaptability to the needs of environmental-based vocational education and cutting-edge technology such as Generative AI. This validation is an important basis for further development, both in terms of content, features, and platform connectivity with the green industry ecosystem.

6. Implementation

The implementation of a green work environment simulation based on Generative Artificial Intelligence is carried out as part of the Work Integrated Learning (WIL) Program at vocational education institutions that carry the concept of an environmentally friendly industry. This simulation is designed to create a virtual learning experience that resembles real working conditions in the green industry sector, while strengthening the integration between theory and practice. The implementation of the simulation involves students from related fields of expertise who follow a work scenario-based learning process using generative AI technology. Measurements are taken at the stages before and after the simulation to see the extent to which participants' competencies have increased in several important aspects of learning.

The following table presents the quantitative results of the implementation process, which show significant improvements in four key variables: understanding of green industry concepts, green work practice skills, learning motivation, and problem-solving abilities.

Table 5. The Effect of Generative AI Simulation on Students' Understanding and Skills

No	Measured Variables	Pre-Simulation Average Score	Post-Simulation Average Score	Increase (%)
1	Understanding the Green Industry Concept	65	85	30%
2	Green Work Practice Skills	60	82	36.7%
3	Motivation to learn	70	90	28.6%
4	Soft Skills (Problem Solving)	62	80	29%

Based on Table 5 shows the results of a quantitative evaluation of the effect of implementing a Generative AI-based simulation on four main variables of student learning outcomes. After participants conducted a green work environment simulation as part of the Work Integrated Learning (WIL) Program, each variable showed a significant increase. For the variable of understanding the concept of green industry, the average score increased by 30% from 65 to 85. This shows that the AI simulation-based approach is effective in helping participants understand the concepts, structures, and practices applied in the green industry. Simulations using AI technology have shown significant improvements in students' conceptual understanding of complex systems, especially in the context of the environment and

industry, by presenting an immersive and interactive experience that cannot be imitated by traditional methods (Kittipanya et al., 2025).

The highest increase in green work practice skills occurred, with a score increasing from 60 to 82, or 36.7%. This indicates that participants gained more in-depth technical experience through real-world work scenario simulations, which are usually difficult to obtain through conventional learning. In addition, learning motivation increased, with scores increasing from 70 to 90 (28.6%). The application of AI-based virtual simulations in vocational training enhances the acquisition of practical skills by providing a realistic scenario-based learning environment that mimics workplace challenges, resulting in better preparedness for tasks in the green industry (Bahaw et al., 2025). This suggests that the use of intelligent technologies such as Generative AI can make education more engaging, encourage active participation, and foster students' curiosity. Meanwhile, soft skills increased from a score of 62 to 80, or 29%. In addition to technical skills, AI-based learning environments support the development of critical thinking and problem-solving skills, which are essential for adapting to the dynamic demands of sustainable industries and green work environments (Bagherimajd et al., 2025). This shows that simulations not only train technical skills but also help people learn to think critically and solve problems in a dynamic work environment. Overall, the data in this table shows that the integration of Generative AI simulations in vocational learning environments is not only effective in improving technical understanding and skills, but also able to strengthen affective and cognitive aspects that are important in work readiness in the green industry era.

E. CONCLUSION

This study has successfully developed and implemented a green work environment simulation utilizing Generative Artificial Intelligence (AI) within the Work Integrated Learning (WIL) Program at a vocational Education institution. The results of the quantitative evaluation showed a significant increase in students' understanding of the concept of green industry, green work practice skills, learning motivation, and soft skills, such as problem-solving, after participating in the simulation. This demonstrates that the use of Generative AI as a learning medium can offer a more interactive, realistic, and adaptive learning experience compared to conventional methods. In addition to enhancing technical competence, this simulation also fosters the development of environmental awareness and the skills necessary to address the challenges of the expanding green industry. These findings confirm that integrating intelligent technology, such as Generative AI, in vocational Education is a strategic step in creating a workforce that is ready and competent in the future green industry. However, the success of this implementation also requires the support of technological infrastructure, educator readiness, and curriculum adjustments that are relevant to current technological developments and industry practices. Therefore, vocational Education institutions need to continue to develop the capacity and resources to adopt this technology optimally.

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REFERENCES

Abo-Khalil, A. G. (2024). Integrating sustainability into higher education challenges and opportunities for universities worldwide. *Heliyon*, *10*(9).

Abulibdeh, A., Zaidan, E., & Abulibdeh, R. (2024). Navigating the confluence of artificial intelligence and education for sustainable development in the era of industry 4.0: Challenges, opportunities, and ethical dimensions. *Journal of Cleaner Production, 437*, 140527.

Adisasmita. (2016). Pembangunan Pedesaan Berbasis Teknologi Informasi Dan Komunikasi. *Risalah*, *27*(2), 62–73.

Ahmed, S., Davis, J., & O'Connor, J. (2024). Industry Perspectives on Project-Based Learning as Work-Integrated Learning in Science Education. *Journal of Teaching and Learning for Graduate Employability*, 15(1), 58-72.

Albay, E. M., & Eisma, D. V. (2021). Performance task assessment supported by the design thinking process: Results from a true experimental research. *Social Sciences & Humanities Open*, *3*(1), 100116.

Al-Fadhli, S. H., & Al-Tamimi, M. A. (2020). Enhancing Vocational Education through Technology Integration: Towards Sustainable Industry Skills. *Journal of Vocational Education & Training*, 72(3), 403–423.

Al-Qaysi, N., Al-Emran, M., Al-Sharafi, M. A., Yaseen, Z. M., Mahmoud, M. A., & Ahmad, A. (2025). Generative AI and educational sustainability: Examining the role of knowledge management factors and AI attributes using a deep learning-based hybrid SEM-ANN approach. *Computer Standards & Interfaces, 93*, 103964.

Arifin, B., Wicaksono, E., Tenrini, R. H., Wardhana, I. W., Setiawan, H., Damayanty, S. A., Solikin, A., Suhendra, M., Saputra, A. H., Ariutama, G. A., Djunedi, P., Rahman, A. B., & Handoko, R. (2020). Village fund, village-owned-enterprises, and employment: Evidence from Indonesia. *Journal of Rural Studies*, *79*(August), 382–394.

Bagherimajd, K., & Khajedad, K. (2025). Designing a model of sustainable education based on artificial intelligence in higher education. *Computers and Education: Artificial Intelligence*. Advance online publication.

Bahaw, P., Forgenie, D., Sadiq, G., & Sookhai, S. (2025). Generative AI for business sustainability: Examining usability, usefulness, and triple bottom line impacts in small and medium enterprises. *Sustainable Futures, 10*, 100815.

Björck, V., & Willermark, S. (2024). Where is the 'WIL'in Work-integrated Learning Research?. *Studies in Continuing Education*, 1-15.

Bolón-Canedo, V., Morán-Fernández, L., Cancela, B., & Alonso-Betanzos, A. (2024). A review of green artificial intelligence: Towards a more sustainable future. *Neurocomputing, 599*, 128096.

Cabral, C., & Dhar, R. L. (2019). Green competencies: Construct development and measurement validation. *Journal of Cleaner Production, 235*, 887–900.

Cederved, C., Ångström-Brännström, C., Ljungman, G., & Engvall, G. (2023). Parents' experiences of having their children take part in participatory action research creating a serious game about radiotherapy. *Radiography*, *29*(1), 95–100.

https://doi.org/10.1016/j.radi.2022.10.005

Contini, G., Grandi, F., & Peruzzini, M. (2025). Human-centric green design for automatic production lines: Using virtual and augmented reality to integrate industrial data and promote sustainability. *Journal of Industrial Information Integration*, *44*, 100801.

Cortés Loyola, C., Adlerstein Grimberg, C., & Bravo Colomer, Ú. (2020). Early childhood teachers making multiliterate learning environments: The emergence of a spatial design thinking process. *Thinking Skills and Creativity*, *36*(November 2019), 100655.

Darna, N., & Herlina, E. (2019). Peningkatan Sumber Daya Manusia Pedesaan Dalam Mewujudkan Desa Mandiri. *ISEI Economic Review*, *III*(2), 66–69.

Du, J., Jing, S., & Liu, J. (2012). Creating shared design thinking process for collaborative design. *Journal of Network and Computer Applications*, *35*(1), 111–120. https://doi.org/10.1016/j.jnca.2011.02.014

El Badriati, B., Saleh, M., Nahar, F. H., Aprilia, T. L., & Azizurrohman, M. (2022). The work ethics of muslim woman Songket weavers in increasing family income: Sukarare tourism village, Indonesia. *Heliyon*, *8*(11), e11604. https://doi.org/10.1016/j.heliyon.2022.e11604

Fogg, C., Lanning, E., Shoebridge, J., Longstaff, J., De Vos, R., Dawson-Taylor, K., Glanville-Hearson, A., Carpenter, D., Court, S., Brown, T., Heiden, E., & Chauhan, A. (2022). The role of Participatory Action Research in developing new models of healthcare: Perspectives from participants and recommendations for ethical review and governance oversight. *Ethics, Medicine and Public Health*, *24*, 100833.

Gumiran, B. A., & Daag, A. (2021). Negotiated participatory action research for multi-stakeholder implementation of early warning systems for landslides. *International Journal of Disaster Risk Reduction*, *58*(March), 102184. https://doi.org/10.1016/j.ijdrr.2021.102184

Gunawan, G., & Nugroho, Y. (2023). Digital business incubation model for rural MSMEs: A sustainability perspective. *Sustainability*, 15(9), 7209.

Hamid, M. A., & Sutrisno, H. (2022). Industry and Vocational School Collaboration: Preparing an Excellent and Industry-Needed Workforce. *TVET@Asia*, Issue 23.

Hidayat, R., & Prasetyo, Z. K. (2024). Simulation-based interactive multimedia to improve vocational students' learning outcomes. *ResearchGate*.

Huang, C.-L., & Liao, C.-C. (2021). Development of a web-based dashboard for parent training intervention: Monitoring and feedback system. *International Journal of Environmental Research and Public Health*, 18(21), 11389.

Hutabarat, Z., & Pandin, M. (2014). Absorptive capacity of business incubator for SME's rural community located in Indonesia's village. *Procedia-Social and Behavioral Sciences*, *115*, 373-377.

Kim, H., & Kim, J. (2021). Designing Interactive Digital Learning Content with Local Cultural Integration: Impacts on Learner Engagement and Sustainability Education. *Computers & Education*, 168, 104203.

Kittipanya-ngam, P., Tan, K. H., & Cavite, H. J. (2025). Future-ready AI: A framework for ethical and sustainable adoption. *Technology in Society, 83*, 102993.

Kushartono, E. W. (2016). Pengembangan Desa Mandiri Melalui Pengelolaan Badan

Usaha Milik Desa (BUMDes) Fitrie Arianti Universitas Diponegoro Semarang. *Jurnal Dinamika Ekonomi & Bisnis*, *12*(1), 67–70.

Li, X. (2024). Innovative integration of sustainable technologies in educational programs: Fostering freshwater production and environmental preservation awareness. *Heliyon, 10*(19), e37978.

Lynch, M., Kamovich, U., Longva, K. K., & Steinert, M. (2021). Combining technology and entrepreneurial education through design thinking: Students' reflections on the learning process. *Technological Forecasting and Social Change*, *164*, 119689.

Nurdin, I., Asrial, A., et al. (2022). *Simulation-based interactive multimedia to improve vocational students' learning outcomes*. World Journal on Educational Technology: Current Issues, 14(2), 508–520.

Nyström, S., & Ahn, S.-e. (2024). Teaching with simulators in vocational education and training – From a storing place to a new colleague. *Teaching and Teacher Education, 138*, 104409.

Prohimi, A. H. A., Nugroho, S. E., & Sari, R. M. (2024). Development of Interactive Learning Media Based on Talent Management for Work-Integrated Learning. *EAI Endorsed Transactions on e-Learning*, 11(4), Article 2350696.

Rashid, A. B., & Kausik, M. A. K. (2024). AI revolutionizing industries worldwide: A comprehensive overview of its diverse applications. *Hybrid Advances, 7*, 100277.

Rokhim, R., & Mayasari, I. (2018). Analisis Model 4as pada Kesediaan Menggunakan Kredit Usaha Rakyat. *Jurnal Kawistara*, *8*(1), 75. https://doi.org/10.22146/kawistara.32171

Saputri, N. P., & Ediyono. (2024). Strategi Pembelajaran untuk Meningkatkan Keterampilan Hijau pada Pendidikan Vokasi dengan Pendekatan Berbasis Proyek dan Berbasis Masalah. *Jurnal Pendidikan Kependidikan*, 10(1), 45-56.

Sari, D. P., & Putra, I. N. (2022). Enhancing Vocational Training through Multimedia Design: A Focus on Language and Visual Elements. *International Journal of Vocational Education and Training*, 28(1), 45-60.

Sari, N., & Oktavianor, T. (2021). Indeks Desa Membangun (Idm) Di Kabupaten Barito Kuala. *Jurnal Administrasi Publik dan Pembangunan*, *2*(1), 36. https://doi.org/10.20527/jpp.v2i1.2768

Somnuke, P., Punpocha, P., Punikhom, P., Panitrat, R., Nivatpumin, P., Thanakiattiwibun, C., Ramlee, R., Thongkaew, N., & Siriussawakul, A. (2023). Model for enhancing the research conducted by the university medical staff: Participatory action research. *Heliyon*, *9*(2), e13208. https://doi.org/10.1016/j.heliyon.2023.e13208

Soori, M., Karimi Ghaleh Jough, F., Dastres, R., & Arezoo, B. (2024). AI-based decision support systems in Industry 4.0: A review. *Journal of Economy and Technology*. Advance online publication.

Suharno, S., Ihsan, F., Himawanto, D. A., Pambudi, N. A., & Rizkiana, R. (2025). Sustainability development in vocational education: a case study in Indonesia. *Higher Education, Skills and Work-Based Learning*, *15*(3), 668-689.

Tzafilkou, K., Perifanou, M., & Economides, A. A. (2022). A systematic review of game-based learning in vocational education and training. *Educational Research Review*, 36, 100443.

Wahyudi, R., & Wicaksono, R. L. (2020). Policy forum: Village fund for REDD+ in

Indonesia: Lessons learned from policy making process at subnational level. *Forest Policy and Economics*, *119*, 102274.

Wang, S., Wang, F., Zhu, Z., Wang, J., Tran, T., & Du, Z. (2024). Artificial intelligence in education: A systematic literature review. *Expert Systems with Applications*, *252*, 124167.

Wicaksono, A., Yunita, I., & Ginaya, G. (2022). Living side by side with nature: evidence of self-governance in three local communities in Indonesia. *Heliyon*, *8*(12).

Xu, J., Jiang, T., Wei, M., & Qing, Z. (2024). The digital transformation of vocational education: Experience and reflections of Shenzhen Polytechnic University. *Vocational and Technical Education*, 1(1).

Yulitasari, Y., & Tyas, W. P. (2020). Village Funds and Village Status in Central Java Province. *Journal of Regional and Rural Development Planning*, *4*(2), 74–83.

Zardari, S., Qasim, M., & Mahmood, K. (2021). Development and validation of e-learning acceptance model based on user experience for sustainable higher education. *Sustainability*, *13*(11), 6201.